PROJECT SUMMARY

Purpose of the research

The primary objective of this Phase I was to demonstrate that a system using a regenerable catalytic reactor, filter, and palladium membrane hydrogen separator is a sensible technology for future manned spaceflight. The goal was to prove this by demonstrating three key operating principles: (1) that a catalytic reactor performing methane pyrolysis can be physically regenerated and used ad infinitum through the automatic removal of carbon build-up, (2) that a filter can safely and efficiently be used to collect and store carbon dust, and (3) that a palladium membrane can be used to separate product hydrogen from the methane stream for ultra-pure hydrogen.

Brief description of the research carried out

The following tasks were completed during the Phase I effort:

- A regenerable, nickel-based catalytic, methane pyrolysis reactor was successfully fabricated and tested. Test results showed that the reactor could be used after cleaning.
- A test setup was fabricated to successfully test the performance of a hydrogen separator based on palladium membrane technology. Test results show better than expected removal rates of hydrogen.
- A carbon removal mechanism was tested and shown to be effective at removing carbon from the reactor walls and providing sufficient regeneration of the catalyst to allow for subsequent methane pyrolysis.
- A test setup was fabricated to test the performance of various filter materials against a test dust to simulate a filter for the removed carbon.

Research findings or results

All technical objectives were met during the Phase I effort. In the Phase I proposal, the technical objectives were:

- Fabricate and test a catalytic reactor to conduct methane pyrolysis
- Run gas sample analysis on the reactor effluent
- Fabricate and test the carbon removal mechanism
- Purchase and test the carbon catching filter
- Investigate the use of a palladium membrane for hydrogen separation

As evidenced by the brief description of the research carried out above, these objectives were met. We were able to demonstrate that a system relying on a regenerable methane pyrolysis reactor and palladium membrane hydrogen separator is feasible.

Significant findings that validate the Phase I effort include:

- That a reactor efficiency of about 10% could be met on a repeatable basis using the same reactor tube (which acts as the catalyst) and carbon removal tool.
- That a tool such as a hone can be used repeatedly to remove carbon and regenerate the nickel surface.

- That a palladium membrane can be used for the expected gas flow streams of methane and hydrogen to efficiently remove hydrogen more than 50% single pass efficiency.

Do the results justify Phase II continuation?

The technology demonstrated during the Phase I effort shows great promise for further research and application. It was demonstrated that the catalytic reactor could indeed be regenerated by a device that removed the carbon build-up and prepared a new catalytic surface. Additionally, the hydrogen separator performed better than expected and used very little power in the process.

Based on the positive results from the benchtop testing conducted, the results do justify a Phase II continuation so that a full-scale prototype can be fabricated and tested.